## TITLE OF THE INVENTION:

MULTIPLE LAMP ILLUMINATION SYSTEM

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims benefit from United States provisional application entitled, "Multiple Lamp Illuminations for Projection Displays", Serial Number 60/390,124, filed June 21, 2002, the contents of which are hereby incorporated by reference.

## BACKGROUND OF THE INVENTION:

**Field of the Invention**

**[0002]** The present invention relates lamp arrangements for projection displays.

**Description of the Related Art**

**[0003]** High power projection devices often employ high power xenon lamps in the multi-kilowatt ranges to a provide screen output of a few thousand lumens. Xenon lamps are inefficient and have long arc gaps at these high output powers. As a result, such units are expensive and bulky.

**[0004]** As an alternative, high power projectors have been designed which include several lower power lamps. For example, lower power metal halide or UHP types of lamps are more efficient, have smaller arc gaps, and cost less. The resulting projector can be more compact, lower in cost, and can produce equal or higher output when compared with xenon lamp systems. Nonetheless, combining the outputs of two or more lamps usually results in a loss of brightness from the lamps, and thus, reduces the efficiency of the system.

**[0005]** Thus, there is a need for new and improved lamp illumination systems for projection display, which have improved efficiency, size and affordability.

## SUMMARY OF THE INVENTION

**[0006]** In accordance with an embodiment of the present invention, an illumination system includes a plurality of lamps, a plurality of first light reflectors, a plurality of second light reflectors, and an output light guide. Each of the first light reflectors is arranged to reflect light output from one of the lamps onto an input of one of the second light reflectors. Each of the second light reflectors is arrange to

direct light from an output of one the first light reflectors into an input of the output light guide, such that the outputs of each of the lamps is combined into a single output.

**[0007]** Further applications and advantages of the present invention are discussed below with reference to the drawing figures.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** Fig. 1 is a diagram of a lamp illumination system according to an embodiment of the present invention;

**[0009]** Figure 2 is a perspective view of the lamp illumination system, according to an embodiment of the present invention;

**[0010]** Figure 3 is a diagram of a lamp illumination system that utilizes light pipes and two elliptical reflector systems according to another embodiment of the present invention;

**[0011]** Figure 4 is a view of an illumination system along the axis of the output light pipe according to another embodiment of the present invention;

**[0012]** Figure 5 is a diagram of an illumination system having extra connecting light pipes added to the input side of the system according to another embodiment of the invention; and

**[0013]** Figure 6 is diagram of a lamp illumination system without input light pipes according to another embodiment of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0014]** According to the present invention, a light pipe system is provided for collecting and combining outputs from two or more lamps into a single output light pipe without loss of brightness. The present invention is well suited to be used with the dual paraboloid reflector system, although the invention is not intended to be limited to such applications. Traditional elliptical reflector systems or paraboloid reflector systems with a focusing lens can also be used. In these latter two case, brightness is partially lost in the elliptical and parabolic reflectors. However, the present invention still preserves the brightness of the light at the input of this system.

**[0015]** Fig. 1 is a schematic diagram of a lamp illumination system using two dual paraboloid reflector systems in accordance with an embodiment of the present invention. The system 100 includes two sets of dual paraboloid reflector (DPR)

systems 102a and 102b. Each DPR system 102 (a,b) includes a DPR 104 (a,b) a lamp 106 (a,b), a retro-reflector 108 (a,b) and a tapered light pipe 110 (a,b). The tapered light pipe may be designed with a convex output surface for further increasing efficiency. A flat output can also be used.

**[0016]** The light output from the arc of each of the lamps 106 (a,b) is reflected and focused by the retro-reflectors 108 (a,b) and DPR 104 (a, b) into a single light beam onto the input of each tapered light pipe 110 (a,b), and is transformed by the light pipe output surface to the desired area and angle. Due to mechanical constraints, the output of each of the light pipes 110 (a,b) may be reflected by 90 degrees, or other appropriate angles, by a reflector means such as a prism 114 (a,b), and coupled into the output light pipe 112. The two inputs to the output light pipe are mixed and produce a final, single output, which preserves the brightness of the arc and a uniform spatial profile for the projection display.

**[0017]** As shown, the output light pipe 112 can be straight, or it can be tapered depending on the output dimension and angle desired. Although the embodiment shows the used of a prism for reflection, other reflective means, like a mirror, can be used. Prisms, however, are preferred because they provide a continuation of the waveguide, which can be more efficient than other reflecting means. The slanting face of each prism 114 (a,b) can be bare in order to provide total internal reflection or can be coated for reflection, depending on the numerical aperture (NA) of the projection system. Fig. 1 shows a gap between the light pipes and the prisms. These gaps can be filled with a clear epoxy or with air, or no gaps may be provided at all.

**[0018]** Fig. 2 shows a perspective view of the light illumination system, according to an embodiment of the present invention. As shown, the input and output light pipes 110 (a,b) are straight. The light pipes can also be tapered as described above with reference to Fig. 1.

**[0019]** In general, the light input to the input light pipes 110 (a,b) can come from a number of sources, such as a DPR system such as shown in Fig. 1, or a tile traditional elliptical reflector or a parabolic reflector with a focusing lens, or both. Each of the lamps 106 can be the same type of lamp and wattage, or can be different types of lamp and/or different wattages, different categories, etc. For example, one lamp 106 can be a 200W xenon lamp, while the other lamp 106 can be

a 100 UHF lamp. In another case, the lamps can be chosen such that the emission spectrum thereof can be different in order to allow adjustment of the emission output with greater freedom.

**[0020]** Fig. 2 shows a gap between the light pipes and the prisms. These gaps can be filled with a clear epoxy or with air, or no gaps may be provided at all.

**[0021]** Fig. 3 is a diagram of another embodiment of the present invention, which utilizes two light pipes and two elliptical reflector systems. This embodiment is similar to the one shown in Fig. 1, except that elliptical reflector systems are used instead of the DPR systems. Light output from lamps 106 (a,b) are each reflected to the input of light pipes 110 (a,b) via the elliptical reflectors 116 (a,b). The outputs from the lamps are combined to produce a single output via prisms 114 (a,b) and output light guide 112.

**[0022]** Fig. 3 shows a small gap between the light pipes and the prisms. These gaps can be filled with a clear epoxy or with air, or no gaps may be provided at all.

**[0023]** The present invention is not intended to be limited to two-lamp configurations as shown above in Figs. 1-3, and other multiple lamp configurations have been contemplated. For example, Figure 4 shows a view of an illumination system along the axis of the output light pipe according to another embodiment of the present invention. In Fig. 4, four lamps are combined into a single output. In this case, four input light pipes 110 (a-d) and four prisms 114 (a-d) direct light from four lamps (not shown) into the output light pipe 112.

**[0024]** Like the embodiments described above, the light pipes 110 can be straight or tapered, and the light input can come from various types of reflectors, etc., to produce the desired output.

**[0025]** Fig. 5 shows a diagram of an illumination system in which extra connecting light pipes are added to the input side of the system according to another embodiment of the invention. Connecting light pipes 118 (a,b) act to change the direction of the input. Depending on the physical implementation, one or more of the inputs can be implemented with the connecting light pipe. These can be applied to the 2-lamp or 4-lamp systems described above, or other multi-lamp systems in accordance with the present invention.

**[0026]** The present invention can be applied to other polygonal input and output light pipes. For example, the input face a triangular output light pipe can be divided

input three portions and a four-faced prism can be used to reflect light from a triangular input light pipe to the output light pipe. A 5-sided output light pipe can also be implemented by arranging five four-faced prisms with five triangular input light pipes. Other polygonal output light pipes can be implemented in a similar fashion.

**[0027]** Although the above embodiments show that the input of the output light pipe 112 is divided equally to receive an equal amount of light from each of the lamps, unequal divisions can also be implemented. For example, when lamps with different arc sizes are used, the input area of the output light pipe can be divided unequally such that the overall output is optimized based on the unequal inputs.

**[0028]** Light pipes can be made from solid glass, quartz, etc., or can be hollow. Lamps used can be metal halide, UHP, mercury, high-pressure mercury, filament, sodium, light emitting diodes (LEDs), etc.

**[0029]** One should understand that in the embodiments described above, the light from the lamps 106 can be directly focused onto the prisms or other combination means without the use of input light guides (tapered light pipes) 110, such as directly from the retro-reflectors 108 (a,b) and DPR 104 (a, b) or via an additional lens or the like. For example, each DPR 102 can be configured to focus light output from lamps 106 directly onto prisms 114, or a lens (not shown) may be added to focus light onto the prisms. As an example, Fig. 6 shows light input directly into prisms 114a and 114b, each of which directs the input light into output light pipe 112.

**[0030]** As shown in Fig. 6, a gap is disposed between the light pipes and the prisms. These gaps can be filled with a clear epoxy or with air, or no gaps may be provided at all.

**[0031]** Thus, the present invention has been fully described with reference to the drawing figures. Although the invention has been described based upon these preferred embodiments, it would be apparent to those of skilled in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention. In order to determine the metes and bounds of the invention, therefore, reference should be made to the appended claims.